3.0 RESULTS

3.1 Passage Through Unmodified (Spillbay 3) and I-Slot (Spillbay 4) Spillbays

3.1.1 Recapture Probabilities

Recapture probabilities of treatment and control groups (physical recapture of both alive and dead fish) were relatively high (>0.94) for the two experiments (Table 3-1). They ranged from 0.941 to 0.974 for the treatment groups and 0.970 for the control. Although chi-square analysis indicated homogeneity in recapture probabilities between trials within both treatment groups and control trials (P>0.05) some variation occurred, particularly with respect to non-recoveries (stationary radio tag signals) and recovery of inflated dislodged tags. In one treatment trial (No. 3) for the unmodified spillbay, 5 of 30 fish (16.7%) showed tag dislodgement or radio signals from them became stationary. In another treatment trial (No. 7) about 10% (4 of 40 fish) exhibited the same fate. Overall, about 5.9% (16 of 270 fish) of the spillbay 3 and 2.6% (7 of 271 fish) of the spillbay 4 treatment fish either had HI-Z tags dislodged or radio tag signals became stationary. Though the sample size was small among the controls, trial Nos. 7 and 8 exhibited a relatively high proportion of fish of unknown status or stationary signals (2 of 20 and 1 of 20, respectively).

Stationary radio signals were received from the area of the location of energy dissipation structures (baffles and end sill) in the stilling basin. To a lesser extent, radio signals on some fish were lost, likely a result of fish occupying >100 ft deep channel about ¼ mile downstream of the spillway. It is suspected that many of the stationary radio signals from this area of the baffles and end sill may have been due to fish entrapment in these structures or collision with them; balloon tags from these fish did not surface. Furthermore, balloon tags and fish did not surface when all spill was curtailed to get a good location fix from these specimens. Underwater examination of the baffles, end sill and areas downstream of the spillway may be warranted to ascertain the integrity of these structures.

The likelihood ratio tests indicated that the recapture probabilities for alive (P_A) and dead (P_D) fish were equal (P>0.05) within each test scenario at 1 h and 48 h (Table 3-2). Thus, for each test scenario the likelihood estimates ofS (probability of fish surviving from release point to recapture), (passage survival), or 1- (passage mortality), andP , with their associated standard errors (SE) were calculated using the simplified model (H_O:P_A=P_D).

3.1.2 Recapture Times

Recapture times (the time interval between release through the induction system until the fish was retrieved) for treatment and control groups were short and similar (Table 3-3 and Figure 3-1). Recapture times averaged less than 8 min for the two treatment conditions and the common control. The variability (as indexed by standard deviations) was greatest among the spillbay 4 treatment group. Some 10 of 264 recaptured fish took longer than 20 min for retrieval (range 22 to 77 min). However, most fish

were retrieved in less than 10 min, well within the criterion specified by the ACOE (Figure 3-1). All alive fish were held for estimating 48 h survival (Table 3-4).

3.1.3 Survival Probabilities

The estimated immediate (1 h) survival probabilities were relatively high but differed slightly between the two test conditions (Table 3-5). The immediate (1 h) survival probability at spillbay 3 was estimated at 0.955 (90% CI=0.9237-0.983) and for the spillbay 4 test it was 0.993 (90% CI=0.972-1.02). The survival probabilities remained the same at 48 h because no mortality of treatment or control fish occurred during this period (Table 3-4). Likelihood ratio test did not reveal significant ($P>0.05$) difference between these survival probabilities).

3.1.4 Injury Classification

For ease of understanding, injured fish were divided into two basic groups: fish with visible cuts and bruises (missing or bulging eyes, hemorrhaging, bruises, etc.) and those with only descaling or loss of equilibrium. A few fish with visible injuries also had major scale loss and/or loss of equilibrium. Each injured fish with a description of its injury is presented in Appendix B.

3.1.4.1 Type of Injuries

All the recaptured treatment and control fish were examined for injury type and general location (Table 3-6 and Figures 3-2 through 3-4). Some 8 of 264 (3.0%) of spillbay 4 treatment fish recovered were visibly injured while 5 of 243 (2.0%) of spillbay 3 treatment fish recovered were injured. Four of 262 (1.5%) controls were injured. Thus, relative to controls, the injury rate attributable to spill was calculated at 1.5% (3.0% minus 1.5%), and 0.5% (2.0% minus 1.5%) for spillbays 4 and 3, respectively. Spillbay 4 treatment fish (accounting for some fish with multiple injuries) incurred the following: injuries to the eyes (4); hemorrhaged gills, cuts or scrapes (5); and bruise on head (3). Spillbay 3 treatment fish exhibited the following injuries: bulging/hemorrhaged eyes (4) and hemorrhaged gills (1). Among the controls the following injuries occurred: bulging/hemorrhaged eyes (1); hemorrhaged gills (1); and bruise/cut on body (1). Although none of the treatment fish exhibited internal injury, one control fish had hemorrhage along the backbone (Table 3-6). Eye injuries were characterized by hemorrhaging and/or bulging (Figure 3-2). Gill area injury (5 treatment, 1 control) consisted of some hemorrhaging and gill covers cut, abraded, or folded back (Figures 3-3 and 3-4). Some hemorrhage-related injuries diminished during the 48 h holding period.

3.1.4.2 Mortality Associated with Injury

Only one spillbay 4 treatment fish and one control fish died during the study and both were dead within 1 h. The control fish had internal damage and hemorrhage at the backbone and the treatment fish had a damaged, bulging eye. All other injured fish were alive and swimming vigorously at 48 h.

3.1.4.3 Possible Cause of Injury

The number of injured fish was relatively small to develop a statistical relationship between the injury type and the causative factor. However, the observed scrape and bruise type wounds were likely caused by physically contacting structural components of the spillbay, tainter gate, baffles, or end sill. Hemorrhaged and bulging eyes could have resulted from collision with these structures or large boulders, if any. Bulging eyes have been typically attributed to pressure effects. However, the absence of other symptoms commonly indicative of pressure changes (expanded or burst air bladder, entrapped gas bubbles, etc.) indicated pressure change may not have been the cause (Cramer and Oligher 1964). One of the four injured control fish had a damaged and bulging eye and because this fish should not have experienced great pressure changes, in our view, the bulging eye was also likely mechanically inflicted. The relatively shallow concrete baffles located in the stilling basin may have accounted for this eye injury and the injuries observed on three other controls. The control hose release point was upstream of both the baffles and the end sill. The injury types and rates observed at spillbays 3 and 4 were similar.

3.1.4.4 Descaling and Loss of Equilibrium

Besides obvious physical injuries noted above, descaling and loss of equilibrium were observed on three spillbay 3 treatment and one control fish (Table 3-7). Descaling was observed on one spillbay 4 treatment fish (Figure 3-4). One control fish exhibited descaling as well as loss of equilibrium. Thus, relative to controls, the spillbay 4 treatment fish incurred no passage-related descaling (0.4% minus 0.4%) while spillbay 3 treatment fish incurred 0.7% (1.1% minus 0.4%) passage-related loss of equilibrium. None of the fish with only descaling or loss of equilibrium died.

3.2 Overflow Spillbay 6 (ACOE Walla Walla Requested Study)

3.2.1 Recapture Probabilities

Recapture probabilities, though relatively high, were slightly lower than expected, particularly for the treatment group (Table 3-8). For the treatment group, recapture probability was 0.943 and that for controls it was 0.962. The lower recapture probability was due to inflated tags recovery dislodged from fish and fish from which stationary radio signals were received but could not be physically recaptured and presumed dead. Some 10 of 210 treatment fish (4.7%) either lost their tags or radio signals became stationary. These fish were assumed dead while 4 of 105 controls (3.8%) had the same fate and were also assumed dead. Chi-square analyses indicated that recapture probabilities were homogenous ($P>0.05$)

between trials within treatment or control groups (Table 3-8). This allowed pooling of data for each trial within group and a calculation of an overall passage survival.

Failure to recapture 4.7% of treatment and 3.8% of controls appeared to be related primarily to effects of the baffles and end sill. Some 3.3% of the treatment fish were suspected to be entrapped in this area as evident from stationary radio signals near these structures in the stilling basin. A similar situation was observed for the tests at spillbays 3 and 4. However, without the benefit of underwater visual observation of the area, exact fish passage problems cannot be identified.

The likelihood ratio test indicated that the recapture probabilities for alive (P_A) and dead (P_D) fish were equal (P>0.05) at 1 h and 48 h (Table 3-9). Thus, the likelihood estimates ofS , , andP with their associated standard errors were calculated using the simplified model (H_O:P_A=P_D). For completeness, however, estimates derived from the generalized model ($H_A: P_A \, NE \, P_D$) are also provided.

3.2.2 Recapture Times

Recapture times for treatment and control groups were short and similar (Table 3-10). Recapture times for treatment fish were 9.9 min and 6.7 min for controls. There was more variation (as indexed by standard deviation) among the treatment group than control group. The higher recapture time for treatment group was primarily due to longer time to recapture four fish (28 to 145 min). None of the controls took longer than 22 min to recapture. Most fish were retrieved in less than 10 min in both groups.

All alive recaptured fish were held in pools to estimate 48 h survival (Table 3-11).

3.2.3 Survival Probabilities

The estimated immediate (1 h) and 48 h survival probabilities were relatively high and identical (Table 3-12); they were estimated at 0.99 (90% CI=0.951-1.0). None of the controls or treatment fish suffered mortality over the 48 h period.

3.2.4 Injury Classification

For ease of understanding, injuries could be categorized into two basic groups: fish with visible cuts and bruises (missing or bulging eyes, hemorrhaging, bruises, etc.) and those with only descaling or loss of equilibrium. None of the treatment fish were classified solely with descaling or lost equilibrium. However, a few fish with visible injuries also were descaled and/or showed loss of equilibrium. Each injured fish with a description of its injury type is presented in Appendix B.

3.2.4.1 Type of Injuries

All the recaptured treatment (198 of 210 or 94.3%) and control (1 of 105 or 96.2%) fish were examined for injury type and general location (Table 3-13 and Figures 3-2 through 3-4). Some 7 of 198 (3.5%) treatment fish recovered were visibly injured while 1 of 101 (1.0%) of the controls were injured. Relative to controls, the injury rate attributable to spill would be about 2.5% (3.5% minus 1.0%). Treatment fish incurred the following: injuries to the eyes (4 fish), bruise on head (1 fish), and bruise on body (3 fish). Eye injuries were characterized by hemorrhaging, bulging. One control specimen exhibited bulging/hemorrhaging eye.

3.3 Passage Through Ice and Trash Sluiceway

As indicated earlier, a limited scope of fish release was made at The Dalles Dam sluiceway to identify any passage problems. No controls were released. A total of 100 fish was released; 97 fish were recaptured alive of which 95 remained alive at 48 h. One fish was recaptured dead while the status of two fish could not be discerned. The average recapture time was about 10 min.

3.3.1 Injuries

The injuries on the recaptured specimens (Table 3-14) indicated some potential for fatal injuries exists. Two recaptured fish had visible injuries; one had lateral line area hemorrhaging and bent body and the other had a bruised nape and operculum. Both were dead within 24 h. It is unknown where in the sluiceway these injuries could have occurred; an inspection of the dewatered sluiceway is needed for further evaluation of causative mechanisms. Additionally, two fish were descaled and showed loss of equilibrium.

3.3.2 Potential Passage Problems at Ice and Trash Sluiceway

Although the sluice appeared relatively benign, the type of injury suggested that not all fish experienced smooth passage. The recapture of a fish with bent body suggests that some fish may have to pass through structurally constricted area(s) in the sluice. Whether such structural constrictions exist can only be confirmed with visual inspection of the sluice after de-watering. This type of fish injury had not been observed in some recent survival studies of fish at sluices or spillbays (Normandeau Associates *et al.* 1995, 1996; Mathur *et al.* 1996b).